PATENT SPECIFICATION (11) 1 526 778

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(21) Application No. 52158/75 (22) Filed 19 Dec. 1975
(31) Convention Application No. 535003
(32) Filed 20 Dec. 1974 in
(33) United States of America (US)
(44) Complete Specification published 27 Sept. 1978
(51) INT CL² A41B 13/02 A61F 13/16 B32B 3/24
(52) Index at acceptance
A5R 83A 83E 83K
B5N 0324 0328 0330 2712

(72) Inventor HUGH ANSLEY THOMPSON

(19)

(54) ABSORPTIVE STRUCTURE

(71) We, THE PROCTER & GAMBLE COMPANY, a Corporation organised and existing under the laws of the State of Ohio, United States of America, of 301 East Sixth Street, Cincinnati, Ohio 45202, United States of America, do hereby declare the invention, for which, we pray that a patent may be granted to and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to topsheets for absorptive devices such as diapers, sanitary napkins, bed pads, incontinence pad, towels and bandages, and, more particularly, to absorptive structures which freely allow fluid to pass into the interior of an absorptive device but which inhibit the reverse flow of fluid. A topsheet is the portion of an absorptive device which covers one face of the absorbent element of an absorptive device and which in some applications contacts the skin of the person using the absorptive device.

Absorptive devices are articles of manufacture designed to receive and retain fluid discharges from a user's body within an absorbent element of the absorptive device. Absorptive devices such as diapers, sanitary napkins, catamenial tampons, bed pads, incontinent pads, towels and bandages are well known articles of commerce. In recent times, single-use disposable absorptive devices have significantly replaced permanent absorptive devices which are designed to be laundered and reused. While the absorptive structure of this invention can be used with reusable absorptive devices, it finds great utility when used with disposable absorptive devices and will be discussed in that context.

Disposable absorptive devices comprising an absorbent pad covered with a topsheet which contacts the body are well known. Covering the outer portion of the absorptive device i.e. the portion which is outermost with respect to the body, with a fluid-impermeable backsheet to prevent absorbed fluids from leaking out of the absorptive device and soiling clothing, bed clothes, etc. is equally well known. The absorbent pad component of disposable absorptive devices can comprise well known materials such as creped cellulose wadding, airlaid felt or the like. The liquid impermeable backsheet can comprise any of various materials well known in the art such as polyethylene film.

One of the principal disadvantages of conventional absorptive devices is the maceration of the skin caused by prolonged contact with absorbed fluids. One especially common manifestation of this maceration is diaper rash generally occurring about the base of the trunk of infants. In order to minimize the effect of prolonged liquid contact with the skin, absorptive devices such as diapers have been produced with the body contacting topsheet thereof designed to exhibit a greater or lesser degree of surface dryness. For example, U.S. patent 3,327,625 teaches that any hydrophobic material in the crotch area of the diaper will cause moisture to wick away from the skin of an infant wearer and thereby provide a substantially dry surface in contact with the infant's skin. U.S. Patent Re 26,151 teaches the use of porous, hydrophobic, non-woven fabrics as topsheets. U.S. patent 2,916,037 is a further example of the use of a non-woven topsheet.

U.S. Patent 3,814,101 discloses a topsheet of a non-fibrous hydrophobic film which is provided with a plurality of valvular slits which restrict the reverse flow of liquid from the absorbent element of the device.

Belgian patent 811,067 describes a liquid-impervious backsheet containing apertured bosses and thus capable of breathing. The apertures therein, so as to maintain the liquid impervious character of the backsheet, are smaller in diameter than the capillaries hereinafter described.

According to the present invention an

absorptive structure for absorbing and containing fluid bodily discharges comprises a topsheet and an absorbent element wherein the topsheet is of a liquid-impervious material provided with tapered capillaries, each capillary having a base in the plane of the topsheet and an apical opening remote from the said plane of the topsheet, an angle of taper (as herein defined) of from 10° to 60°, a base opening dimension (as herein defined) of from 0.006 to 0.25 inches and an apical opening dimension (as herein defined) of from 0.004 to 0.100 inches and wherein the absorbent element is in intimate contact with the apical openings of the tapered capillaries.

It is found that such a structure is an improvement over previous such structures in that it allows the free transfer of fluids from the body into the absorbent element of the device while inhibiting the reverse flow of these fluids, thereby providing a relatively much dryer surface in contact with the user than has been previously obtainable. While directed primarily to single-use, disposable absorptive devices such as disposable diapers, an absorptive structure according to the invention can be used with re-usable absorptive devices such as cloth diapers.

An absorptive device in accordance with the invention is particularly comfortable when in contact with the skin of the user, primarily because it presents a surface to the wearer thereof which is dryer than has been previously obtainable.

An example of an absorptive structure in accordance with the invention will now be described in more detail, with reference to the accompanying drawings, in which:—

Figure 1 is a perspective representation of an unfolded disposable diaper with portions of its components cut away;

Figure 2 is an enlarged fragmentary perspective view of a tapered capillary forming part of the structure of the diaper of Figure 1;

Figure 3 is a cross-section in elevation of the tapered capillary taken along the line 3—3 in Figure 2; and Figure 4 is a cross-section of the tapered capillary as shown in Figures 2 and 3, but here shown in intimate contact with an absorbent element.

While the description that follows is primarily concerned with the use of an absorptive structure in accordance with the invention in a disposable diaper, it should be understood that it also has substantial utility in a wide variety of absorptive devices, both disposable and reusable, such as sanitary napkins, catamenial tampons bed pads, incontinent pads, towels, bandages and the like.

Figure 1 shows a disposable diaper 21. Various layers have been cut away to more clearly show the structural details.

The topsheet of the structure is shown at 22. The other two major components of the disposable diaper 21 are an absorbent element or pad 23 and a backsheet 24. In general, side flaps 25 of the backsheet 24 are folded so as to cover the edges of the absorbent pad 23 and topsheet 22. Topsheet 22 is generally folded to completely enclose the ends of absorbent pad 23.

The drawing of diaper 21 in Figure 1 is a simplified representation of a disposable diaper. A more detailed description of a preferred embodiment of a disposable diaper is contained in the aforementioned U.S. patent Re. 26,151.

The topsheet 22 is constructed from a liquid impervious material. An example of a suitable liquid impervious material is low density polyethylene of from 0.001 to 0.002 inch (0.0025 to 0.0051 centimetre) thickness. The topsheet 22 is provided with tapered capillaries as hereinafter described and for convenience in the following description the term "topsheet" is used to cover both the sheet itself and also the associated capillaries.

Tapered capillaries 26 are shown in perspective in Figure 2 and in cross-section in Figure 3. While tapered capillary 26 is shown in Figures 2 and 3 as generally in the form of a frustum of a conical surface, it is to be understood that any generally tapered structure, such as a frustum of a pyramid or the like with a triangular, square or polygonal base, is within the scope of the invention; circular, tapered capillaries, however, are used in this description for convenience in explaining the manifold advantages of the invention. For the purposes of the invention except as defined below, the angle of taper is taken to be the angle subtended by the intersection of an axis extending perpendicularly to the plane of the topsheet and the straight-walled side of the capillary extending from the base opening towards the point of minimum apical opening in the plane of said axis. It is also to be understood that the tapered capillaries can be asymmetric (i.e. the angle of taper on one side can be different from that on another side, provided that each of two opposed sides forming the tapered capillary has a taper angle within the range as herein defined) and that the angle of taper can change continuously (i.e. the sides may be curved) over the distance from base 30 to apical opening 29. In the latter case, the angle of taper is defined as the angle between the tangent to the side of the capillary at its point of minimum apical opening dimension and the axis referred to above. Also included in the term tapered capillary is a slot formed into topsheet 22,

the slot having a finite length less than the width of topsheet 22 and having its sides and ends tapered at angles analogous to those hereinafter described in relation to a circular tapered capillary.

The angle of taper is represented by α in Figure 3. The angle of taper suitable for use in the topsheet is from 10° to 60°.

The base opening dimension, except for the hereinbefore mentioned slot is defined as the maximum open measurement in the plane of topsheet 22 of the tapered capillary 26. The apical opening dimension, except for the hereinbefore mentioned slot, is defined as the maximum open measurement in the apical opening of tapered capillary 26 which apical opening is remote from the plane of the topsheet 22. When the tapered capillary is in the form of a frustum of a conical surface, the base and apical opening dimensions are, respectively base diameter 28 and apical opening diameter 27. "Base diameter" and "apical opening diameter" are hereinafter used inter-changeably with, respectively, "base opening dimension" and "apical opening dimension".

When the tapered capillary of this invention is in the form of a slot of length more than 0.25 inches, the terms "base opening dimension" and "apical opening dimension" refer respectively to the width of the base of the slot in the plane of the topsheet and the apical opening of the slot remote from the plane of the topsheet 22. That is, base and apical opening dimensions refer to the width rather than to the length of the slot.

Tapered capillary apical opening diameter 27 is a diameter which will allow liquid to readily pass from the surface of topsheet 22 to absorbent pad 23. Apex diameter 27 is from 0.004 to 0.100 inch (0.010 to 0.254 centimeter), preferably from 0.005 to 0.020 inch (0.013 to 0.051 centimeter).

Tapered capillary base diameter 28 is selected to satisfy two criteria. The first of these is the subjective feel of the surface of the topsheet which contacts the skin of the user. It has been discovered that the aforementioned polyethylene can be made to exhibit pleasing, clothlike, non-waxy attributes when base diameter 28 is within the range from 0.006 to 0.250 inch (0.015 to 0.635 centimeter). Preferably base diameter 28 should be within the range of 0.030 to 0.060 inch (0.076 to 0.152 centimeter). The second criterion is that the capillary base diameter be small enough to allow an expected liquid droplet to bridge across at least one capillary. This criterion is satisfied by the above dimensions for disposable diapers.

The height of the tapered capillary is defined as the distance between the outermost surface of topsheet 22 (i.e., that surface which normally contacts the skin of the user) and the apex 29 of tapered capillary 26. This height, of course, depends upon apex diameter 27, base diameter 28, and angle of taper α which have been selected as hereinbefore described. The height of the tapered capillary should provide a structure with a minimal tendency to collapse in use. The characteristics of the material of construction of topsheet 22 in large measure determine suitable ranges for the height. When topsheet 22 is low density polyethylene of from 0.001 to 0.002 inch thickness and apex diameter 27 and base diameter 28 are in the preferred range, and angle of taper α is in its critical range, the height of the tapered capillary can be from 0.003 to 0.159 inch (0.008 to 0.404 centimeter).

It is necessary that the apical opening 29 of the tapered capillary 26 be in intimate contact with absorbent pad 23.

Practical absorptive devices such as disposable diapers must be constructed so there is no reverse flow of fluid when the absorbent element is placed under pressure as by an infant sitting on or moving about in a wet disposable diaper. Protection from this pressure-induced reverse flow is obtained if the absorbent element is constructed so as to be less than totally saturated at its expected maximum fluid content. That is to say, the absorbent element should be designed and constructed to contain a significantly larger quantity of fluid than it is anticipated that the absorptive device will be required to contain in a practical use situation. For the preferred absorptive pad described hereinafter, a practical anticipated liquid loading of from 3 times to 6 times the dry weight of the pad is satisfactory. It should be noted that this permissible loading is somewhat higher than that which is acceptable because of surface wetness characteristics when the usual non-woven topsheet is used with a disposable diaper. One benefit from this increased loading is a possible net reduction in the amount of material used in the absorbent pad of this invention as compared to that used in ordinary disposable diapers.

Another necessary criterion is apparent to those skilled in the art: the topsheet must allow rapid transfer of liquids through it, This rate of transfer depends on several variables such as rate of fluid discharge from the body, viscosity of the fluid, fraction of open area of the topsheet, minimum diameter of tapered capillaries, and so forth. The proper combination of parameters for any given application can

readily be determined by simple experimentation. The preferred dimensions recited herein for disposable diaper topsheets insure rapid transfer of urine into the absorbent element.

A state of relative dryness on the surface of the topsheet implies that most of the liquid which contacts the topsheet is transferred through it to the absorbent element. This in turn implies that each isolated droplet of fluid in contact with the topsheet must be in contact with the base diameter of a tapered capillary. This state of affairs can best be achieved if the land area (i.e. the area of the topsheet that exists between the bases of the tapered capillaries) is as small as practicable. The minimum limiting value is the case where conical tapered capillaries or pyramidal tapered capillaries are provided in close packed array (where the periphery of the base 30 of each capillary is in contact with the periphery of the base 30 of each adjacent capillary). The preferred arrangement of land area tends to insure that an individual droplet will contact at least one tapered capillary. A preferred arrangement in disposable diapers is where the tapered capillaries as hereinbefore described are in ordered arrangement with from 30 to 1500 tapered capillaries per square inch of topsheet (5 to 231 per square centimeter).

Topsheet 22 provided with tapered capillaries 26 can be manufacture in any of several ways well known in the art. One particularly suitable method is to provide a heated mold (hereinafter referred to as a pin mold) with male elements of the shape and arangement of the desired tapered capillaries. Each male element is secured in such a fashion that its apex extends away from the base of the mold. A portion of liquid-impervious material is brought into contact with the heated mold between the mold and a resilient backing plate. Pressure is applied to the combination of mold, liquid-impervious material and resilient back plate and tapered capillaries are formed in the liquid impervious material to make the topsheet described herein. An alternative way of constructing the topsheet of this invention is to subject a portion of liquid-impervious material to vacuum forming over an appropriate mold by means well known in the art. A third way of making topsheet 22 for use in this invention is to cast the topsheet on a mold designed for the purpose and similar to that previously described. After forming tapered capillary structures in one of the three aforementioned ways, it may be necessary to physically remove material from the apex of the tapered capillary structure so as to insure that the apex diameter is the desired value. Such removal of material can be accomplished by, for example, subjecting the apex to controlled abrasion or by heating the formed topsheet so as to melt open the apex.

Absorbent pad 23 of the disposable diaper exemplified in Figure 1 can comprise materials commonly used in absorptive devices and well known to the art. A preferred form of suitable absorbent material for the pad 23 comprises comminuted wood pulp generally referred to as airfelt. When airfelt is used, the tissue paper envelope commonly present in disposable diaper applications can be omitted. Other materials can also be used for the absorbent pad 23 such as a multiplicity of plies of creped cellulose wadding and any equivalents thereof.

As described hereinbefore, absorbent pad 23 must be in contact with the apex 29 of the tapered capillary 26 of the topsheet of this invention. Further, the absorbent pad 23 must absorb the liquid from apex 29 of the tapered capillary 26.

Liquid impervious backsheet 24 can be any material well known in the art. A preferred material is low density polyethylene 0.001 to 0.002 inch (0.0025 to 0.0051 centimeter) thick.

The elements of the finished disposable diaper—tapered capillary topsheet 22, absorbent pad 23 and optional elements such as liquid-impervious backsheet 24—can be assembled into a practical, economical disposable diaper by means well known in the art. An example of such union into disposable diapers is described in the hereinbefore incorporated U.S. Patent Re 26,151.

As noted, the tapered capillary topsheet herein described has been exemplified in terms of a disposable diaper. Other absorptive devices well known in the art such as sanitary napkins, catamenial tampons, bed pads, incontinent pads, towels, bandages and the like can be advantageously constructed using the tapered capillary topsheet herein described. Specific examples of sanitary napkins and catamenial tampons wherein this topsheet can be used can be found in U.S. Patent 3,800,797 issued to Tunc on April 2, 1974 and U.S. Patent 3,815,601 issued to Schaefer on June 11, 1974.

In order to contribute to a better understanding of this invention and not by way of limitation, the following examples are provided.

EXAMPLE I

Conical tapered capillaries having a base diameter of 0.040 inch and an apex diameter of 0.012 inch and an angle of taper of 45° were formed using a pin mold, in a

sheet of 0.0015 inch thick "Surlyn" (Registered Trade Mark), a liquid-impervious ionomer film made by the E. I. du Pont de Nemours and Company. A total of 722 capillaries per square inch in regular array were impressed into the film. The topsheet was placed so that the apices of the tapered capillaries were in contact with an absorbent pad made from airlaid softwood fibers. The resulting absorbent structure allowed droplets of saline solution to pass through the topsheet into the absorbent pad. The free surface of the topsheet exhibited a dry feel and was pleasing to the touch.

EXAMPLE II

Example I is repeated, except that 320 conical tapered capillaries having a base diameter of 0.060 inch and an apex diameter of 0.012 inch and an angle of taper of 45° are formed in a regular array into each square inch of respectively, "Surlyn" (Registered Trade Mark), and low density polyethylene 0.0015 inch thick. Essentially the same results are observed.

EXAMPLE III

Pyramidal tapered capillaries having a square base 0.050 inch on each side and a square apex 0.012 inch on each side and an angle of taper of 45° were embossed into 0.0015 inch thick low density polyethylene film. A total of 400 tapered capillaries per square inch of film were used. Essentially the same results as in Example I were observed when the topsheet was placed in contact with the airfelt of Example I. Further, this absorbent structure was used in the construction of a disposable diaper made according to the teaching of Duncan et al in the aforementioned Re. 26,121. When used in a practical way on infants, the disposable diaper exhibited a drier, more comfortable surface in contact with the infant than can be obtained with a conventional hydrophobic non-woven topsheet.

EXAMPLE IV

Example II, including the bringing of the apices of the formed cones into contact with an absorbent airfelt, is repeated using formed cones having base diameter, apex diameter, angle of taper, and number of capillaries per square inch, respectively, as follows: 0.030 inch, 0.010 inch, 45°, 1280; 0.060 inch, 0.012 inch, 60°, 320; and 0.100 inch, 0.015 inch, 30°, 74. Satisfactory results in terms of transfer of fluid and dry surface feel are obtained.

WHAT WE CLAIM IS:—

1. An absorptive structure for absorbing and containing fluid bodily discharges, comprising a topsheet and an absorbent element wherein the topsheet is of a liquid-impervious material provided with tapered capillaries, each capillary having a base in the plane of the topsheet and an apical opening remote from the said plane of the topsheet, an angle of taper (as herein defined) of from 10° to 60°, a base opening dimension (as herein defined) of from 0.006 to 0.25 inches and an apical opening dimension (as herein defined) of from 0.004 to 0.100 inches and wherein the absorbent element is in intimate contact with the apical openings of the tapered capillaries.

2. An absorptive structure as claimed in Claim 1 wherein the base opening dimension is from 0.03 to 0.06 inches and the apex opening dimension is from 0.005 to 0.02 inches.

3. An absorptive structure as claimed in either one of Claims 1 and 2 wherein the tapered capillaries are in the form of frustums of conical surfaces.

4. An absorptive structure as claimed in any one of the preceding claims in the form of a disposable diaper.

5. An absorptive structure as claimed in any one of the preceding claims including a fluid-impervious backsheet.

6. An absorptive structure substantially as described with reference to the examples.

7. An absorptive structure in the form of a disposable diaper substantially as described and illustrated in the accompanying drawings.

For the Applicants:
GILL JENNINGS & EVERY,
Chartered Patent Agents,
53/64 Chancery Lane,
London WC2A 1HN.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1978
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1526778 COMPLETE SPECIFICATION
1 SHEET

Fig. 1

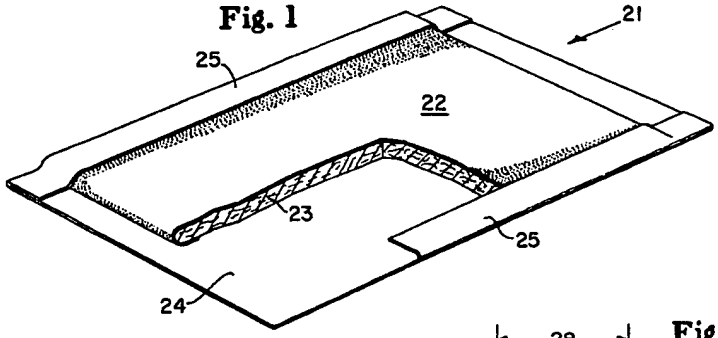

Fig. 2

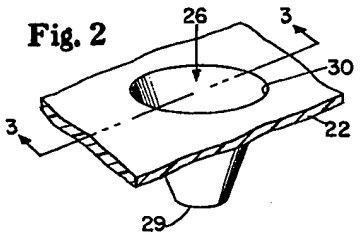

Fig. 3

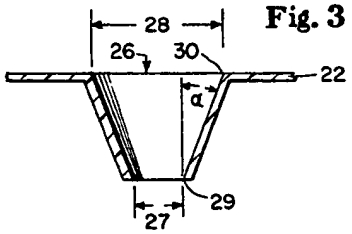

Fig. 4